

providing a first and second tubular members having overlapping longitudinal slots; and
coupling the sleeve to corresponding threads on an outer surface of the first and second tubular members.

27
(continued)

REMARKS

This is intended as a full and complete response to the Office Action dated June 19, 2002, having a shortened statutory period for response set to expire on September 19, 2002. Claims 1, 3-6, and 16-26 are pending in the application. Please enter the following amendments and reconsider the claims pending in the application for reasons discussed below.

Claims 16-18 and 20-26 are objected to because of informalities. Although Applicant believes his use of "tubular" as a noun is correct, as supported by the numerous issued patents to date, including U.S. Patent No. 6,431,282 recently issued on August 13, 2002, the Applicant has amended the claims in accordance with the Examiner's comments to expedite the allowance of this application.

Claims 1, 3-6, and 16-26 are rejected under 35 U.S.C. § 112, second paragraph. Where appropriate, Applicant has amended the claims for clarification in accordance with the Examiner's comments.

Claims 1, 3-4, 16-18, and 22 stand rejected under 35 U.S.C. § 102(a) as being anticipated by *Lohbeck*, WO 98/22690. The Examiner states that *Lohbeck* discloses an expandable tubing assembly comprising a tubular connector defining overlapping longitudinal slots and comprising an intermediate portion (area where 1 is pointing in Figure 1) located between slotted end portions, the connector being radially expandable by deformation of fingers of material in the intermediate portion where adjacent circumferentially spaced slots overlap, and where the slotted end portions of the connector 1 are threaded to the nodes of respective end portions (threaded via screws 11) of the tubing lengths and the deformable fingers of the connector are axially spaced from the end most deformable fingers of the respective tubing lengths.

Applicant respectfully traverses this rejection on the ground that *Lohbeck* is not proper prior art under 35 U.S.C. § 102(a). In order for § 102(a) to apply, a reference must have a publication date earlier in time than the effective filing date of the Applicant's application. See MPEP § 706.02(a). The effective filing date of a national stage application filed under 35 U.S.C. § 371 is the filing date of the international application designating the U.S. See MPEP § 1893.03(b).

In the present case, the Examiner has not established a prima facie case that *Lohbeck* is proper prior art under 35 U.S.C. § 102(a). The present application is the national stage filing under § 371 of International Application number PCT/GB98/00863 having an international filing date of March 20, 1998. See Filing Receipt. Thus, the present application has an effective filing date of March 20, 1998. *Lohbeck* was published on May 28, 1998. Because *Lohbeck* was published after the effective filing date of the present application, *Lohbeck* is not proper prior art under § 102(a). Therefore, Applicant respectfully requests withdrawal of the rejection and allowance of the claims.

Claims 5-6, 19-21 and 23-26 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Lohbeck* in view of *Kozono*, U.S. Patent No. 4,619,472. The Examiner states that *Lohbeck* does not disclose each end portion defines an internal thread for engaging a corresponding thread on an outer surface of each tubing end portion. The Examiner states that *Kozono* discloses inner threads at both ends of a connector and external threads on adjacent pipe ends in order to create a strong connection between two tubes which can be quickly assembled. Therefore, the Examiner concludes that it would have been obvious to modify the connector in *Lohbeck* to include the mating internal and external threads with a groove and tongue arrangement in order to create a strong connection.

Applicant respectfully traverses this rejection. As discussed above, *Lohbeck* is not proper prior art. Therefore, Applicant respectfully requests withdrawal of the rejection. Further, *Kozono* discloses pipe coupling having an inner tubular member cut with an external thread and an outer tubular member cut with an internal thread and posses a sealing portion where the metal to metal contact of conical surfaces establishes a seal. The tip of the sealing portion of the inner tubular member is

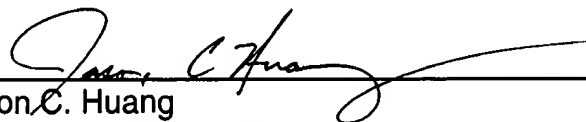
substantially not in contact with the tip of the outer tubular member. *Kozono* does not teach, show, or suggest an expandable slotted tubular or a how the threads may be implemented to connect an expandable slotted tubular.

Claims 5-6 depend from claim 1 and claims 19-21 depend from claim 16. As discussed above, Applicant believes claims 1 and 16 are in condition for allowance. Therefore, Applicant believes claims 5-6 and 19-21 are also in condition for allowance. Further, the references, neither alone nor in combination, teach, show, or suggest the connector end portions define grooves to receive corresponding tongues provided on the tubing length end portions as recited in claim 6 and 20. Additionally, the references, neither alone nor in combination, teach, show, or suggest an intermediate portion located between the first and second ends having a plurality of radially spaced, longitudinal slots that at least partially overlap the slots formed in the first and second ends as recited in claims 23-26. Therefore, Applicant believes the claims are in condition for allowance and respectfully request allowance of the same.

With regards to the objected Specification, Applicant has attached a clean version of the Substitute Specification and a marked up version of the Substitute Specification showing changes made to the originally filed Specification.

In conclusion, the references cited by the Examiner, neither alone nor in combination, teach, show, or suggest the apparatus or process of the present invention. Having addressed all issues set out in the office action, Applicant respectfully submits that the claims are in condition for allowance and respectfully request that the claims be allowed.

Respectfully submitted,


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APPENDIX

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Marked Up Version Showing Amendments to the Claims:

1. (Amended) An expandable tubing assembly comprising:

a tubular connector defining overlapping longitudinal slots and comprising an intermediate portion located between slotted end portions, the connector being radially expandable by deformation of fingers of material in the intermediate portion where adjacent circumferentially spaced slots overlap, and

lengths of expandable tubing defining overlapping longitudinal slots with nodes beyond the ends of the tubing slots and having slotted end portions, the tubing being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap,

wherein the slotted end portions of the connector are threaded to the nodes of respective end portions of the tubing lengths and the deformable fingers of the connector are axially spaced from the [end most] deformable fingers proximate the slotted end portions of the respective tubing lengths.

16. (Twice Amended) An expandable tubing assembly, comprising:

a first and second [tubulars] tubular members having a plurality of longitudinal slots formed therein;

a connector threadably disposed between the first and second [tubulars] tubular members, wherein the connector comprises:

first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots formed therein; and

an intermediate portion located between the first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots that at least partially overlap the slots formed in the first and second ends.

17. (Amended) The assembly of claim 16, wherein the slots formed in the first [tubular] tubular member, the second [tubular] tubular member, and the intermediate portion are expandable.

18. (Amended) The assembly of claim 17, wherein the slots formed in the first [tubular] tubular member, the second [tubular] tubular member, and the intermediate portion are expandable to form substantially diamond shaped apertures.

20. (Amended) The assembly of claim 19, wherein the threaded inner surface of the first and second ends of the connector engage a corresponding thread on an outer surface of the first and second [tubulars] tubular members.

21. (Amended) The assembly of claim 20, wherein the first and second ends of the connector include a recessed groove that receives a tongue disposed on an end of the first and second [tubulars] tubular members.

22. (Twice Amended) The assembly of claim 16, wherein the connector is attached to the first and second tubulars using one or more means for connecting disposed between the [radially] circumferentially spaced, longitudinal slots formed in the first and second ends of the connector.

23. (Twice Amended) An expandable tubing assembly, comprising:
a first and second [tubulars] tubular members having a plurality of longitudinal slots formed therein;
a connector disposed between the first and second slotted [tubulars] tubular members, wherein the connector comprises:
first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots formed therein, wherein an inner surface of the first and second ends of the connector is threaded; and

an intermediate portion located between the first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots that at least partially overlap the slots formed in the first and second ends,

wherein the threaded inner surfaces of the first and second ends of the connector engage a corresponding thread on an outer surface of the first and second [tubular] tubular members.

24. (Amended) The assembly of claim 23, wherein the slots formed in the first [tubular] tubular member, the second [tubular] tubular member, and the intermediate portion are expandable to form substantially diamond shaped apertures.

25. (Amended) An expandable tubing assembly, comprising:

a first and second [tubular] tubular members having a plurality of longitudinal slots formed therein;

a connector disposed between the first and second slotted [tubulars] tubular members, wherein the connector comprises:

first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots formed therein, wherein an inner surface of the first and second ends of the connector is threaded and wherein the first and second ends of the connector include a recessed groove; and

an intermediate portion located between the first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots that at least partially overlap the slots formed in the first and second ends,

wherein the threaded inner surfaces of the first and second ends of the connector engage a corresponding thread on an outer surface of the first and second tubular and each recessed groove receives a corresponding tongue disposed on an end of the first and second [tubulars] tubular members.

26. (Amended) A method for coupling an expandable tubing assembly, comprising:
providing a sleeve comprising:

first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots formed therein, wherein an inner surface of the first and second ends of the connector is threaded and wherein the first and second ends of the connector include a recessed groove; and

an intermediate portion located between the first and second ends having a plurality of [radially] circumferentially spaced, longitudinal slots that at least partially overlap the slots formed in the first and second ends,

providing a first and second [tubular] tubular members having overlapping longitudinal slots; and
coupling the sleeve to corresponding threads on an outer surface of the first and second [tubular] tubular members.

**MARKED UP VERSION SHOWING CHANGES TO THE SUBSTITUTE
SPECIFICATION**

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**EXPANDABLE SLOTTED TUBING STRING
AND METHOD FOR CONNECTING SUCH A TUBING STRING**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage of International Application No. PCT/GB98/00863, filed on March 20, 1998 and published under PCT Article 21(2) in English, and claims priority of United Kingdom Applications No. 9705928.1 filed on March 21, 1997 and No. 9723338.1 filed on November 4, 1997.

BACKGROUND OF THE INVENTION

Field of the Invention

~~[0001]~~[0002] This invention relates to a connector, and in particular to a connector forming part of an expandable tubing assembly. The invention also relates to a method of connecting lengths of expandable tubing.

Description of the Related Art

~~[0002]~~[0003] W09325800 describes expandable tubing defining overlapping longitudinal slots. On expansion of the tubing, by pushing or pulling a mandrel through the tubing, the slots expand to form diamond-shaped apertures. The expansion is accommodated by deformation of the fingers of metal between the slots, this deformation taking place predominantly at the slot ends, and also by circumferential extension of the parts of the tubing wall beyond the slot ends. In expandable tubing developed by the applicants radial expansion is achieved with the parts of the tubing wall between and beyond the slot ends experiencing little if any deformation, these parts being known as the tubing "nodes".

[0003][0004] Arrangements for connecting lengths of slotted tubing are disclosed in W096\37687 and W097\21901, the disclosures of which are incorporated herein by reference. Both of these documents describe arrangements in which the end of one length of tubing defines a male coupling portion which is received within a female coupling portion on the other length of tubing and attached thereto.

[0004][0005] In another coupling arrangement, the ends of the tubing lengths are received within an external coupling sleeve. However, it has been found that, following expansion, the sleeve contracts radially by a significant extent; this creates a restriction in the bore defined by the tubing.

SUMMARY OF THE INVENTION

[0005][0006] According to the present invention there is provided a method of connecting lengths of expandable tubing defining overlapping longitudinal slots, the method comprising: providing a tubular connector defining overlapping 10 longitudinal slots and comprising end portions; providing lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots and connecting the connector end portions to nodes of respective end portions of the tubing lengths.

[0006][0007] According to another aspect of the present invention there is provided an expandable tubing assembly comprising: a tubular connector defining overlapping longitudinal slots and comprising end portions; lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots; and the connector end portions being; coupled to the nodes of the respective end portions of the tubing lengths.

[0007][0008] The formation of the connections between the connector end portions and the nodes of the tubing end portions provides for a relatively secure connection. Preferably, the connector end portions and the nodes of the tubing end portions are threaded, and the absence of significant deformation at the nodes facilitates

maintenance of a secure connection on expansion of the tubing lengths and the connector.

[0008][0009] Preferably also, the connector further comprises an intermediate portion selected to be of corresponding configuration to the tubing lengths, such that the expansion characteristics of the connected tubing assembly will be substantially constant over the connection.

[0009][0010] Preferably also, each connector end portion defines a slot to receive a corresponding tongue provided on the respective tubing length end portion.

[0010][0011] According to a further aspect of the present invention there is provided an expandable tubing assembly comprising: a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion; and lengths of expandable tubing defining overlapping longitudinal slots and having end portions coupled to the connector end portions, at least the connector intermediate portion being of corresponding configuration to the tubing lengths, such that the expansion characteristics of the intermediate portion and the tubing lengths correspond.

[0011][0012] This aspect of the invention provides a connector which expands in a compatible manner to the adjacent tubing and thus facilitates reliable expansion of an expandable tubing string.

[0012][0013] According to still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a sleeve defining overlapping longitudinal slots, first and second tubing lengths defining overlapping longitudinal slots, in use the sleeve and tubing lengths being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths, the deformable fingers of the sleeve being axially spaced from the endmost deformable fingers of the respective tubing lengths.

[0013][0014] In use, on expansion of the tubing lengths and the sleeve, the deformation of the sleeve fingers will take place following the deformation of the endmost fingers of the first tubing length and prior to the deformation of the endmost fingers of the second tubing length. It has been found that, following expansion, there is little or no diametrical shrinkage of the sleeve, and the force necessary to expand the coupled tubing ends is approximately half that required to expand tubing ends coupled with a sleeve in which there is substantial overlap between the sleeve and the tubing ends.

[0014][0015] The invention also relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of: providing a sleeve defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap; coupling the sleeve to the ends of first and second lengths of expandable tubing such that the fingers of the sleeve are longitudinally spaced from the endmost fingers of the tubing lengths; and forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

[0015][0016] As used herein, the term slots is intended to encompass slots which extend through the walls of the sleeve and tubing, slots which extend only part way through the walls and any other appropriate weakening of the walls such as lines of bores or scallops.

[0016][0017] Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve beyond the respective endmost tubing fingers. The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

~~[0017]~~[0018] Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

~~[0018]~~[0019] According to a still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a longitudinally slotted sleeve[,] and first and second tubing lengths defining overlapping longitudinal slots. In use, [in use] the tubing lengths [being]are radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths.

~~[0019]~~[0020] The sleeve may be in the form of longitudinally extending strips of metal. Most preferably, the strips are rectilinear. On expansion, the strips of the sleeve move radially outwardly and separate circumferentially. Initially, that is prior to expansion, the strips may be circumferentially connected, by frangible links 119 such as wire, webs of material or one or more welds, to facilitate sleeve handling.

~~[0020]~~[0021] The invention further relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of: providing a sleeve comprising longitudinally extending strips of material; coupling the sleeve to the ends of first and second. lengths of expandable tubing; and forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

~~[0021]~~[0022] Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve. The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

[0022][0023] Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023][0024] Aspects of the present invention will now be described, by way of example, with reference to the accompanying; drawings, in which:

Figure 1 is a sectional view of a length of expandable tubing, shown in an expanded configuration;

Figure 2 is a sectional view of an expandable tubing assembly in accordance with a first embodiment of the present invention;

Figure 3 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a second embodiment of the present invention;

Figure 4 is a sectional view of Figure 3; and

Figure 5 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0024][0025] Reference is first made to Figure 1 of the drawings, which illustrates a length of expandable tubing 10. In its initial configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined. Applying a radially outward force to the tubing wall, by passing a mandrel through the tubing, causes the tubing to expand such that the slots 12 become diamond-shaped openings.

[0025][0026] The tubing 10 is supplied in lengths suitable for transportation and handling and these are joined to one another on surface to create a tubular string. The assembly 14 illustrated in Figure 2 of the drawings allows lengths of expandable tubing 10 to be connected to form a string, as will now be described.

[0026][0027] The assembly 14 comprises a tubular connector 16 defining overlapping longitudinal slots 18, the connector 16 comprising end portions 20, 21 and an

intermediate portion 22. The slots 18 extend over the whole length of the connector 16, but the only slot overlap occurs in the intermediate portion 22.

[0027][0028] The connector 16 is utilized to join the ends of two lengths of expandable tubing 24, 25, the ends of which are adapted to engage with the connector end portions 20, 21 as described below.

[0028][0029] The connector intermediate portion 22 is of substantially the same wall thickness as the tubing 24, 25, however the connector end portions 20, 21 are upset, that is they include portions of greater wall thickness than the tubing 24, 25 and are of a greater diameter than the tubing 24, 25. The inner walls of each connector end portion 20, 21 define threads 26, 27 for engaging corresponding threads 28, 29 on the outer surface of the tubing 24, 25. Inwardly of the threads 26, 27 the end portions 20, 21 define grooves 30, 31 to receive corresponding tongues 32, 33 provided on the ends of the tubing lengths 24, 25.

[0029][0030] As noted above, the connector slots 18 only overlap in the intermediate portion 22, such that on expansion of the connector 16 and the tubing lengths 24, 25 the connector 16 is only subject to significant deformation in the intermediate portion 22, at and adjacent the slot overlap 34. The amount of deformation is substantially lower in the rest of the connector 16, particularly in the "nodes" 36 between the ends of the longitudinally aligned slots 18. The tubing lengths 24, 25 feature nodes 38 between and beyond the ends of the tubing slots 12 and the tubing threads 28, 29 are formed on the end most tubing nodes.

[0030][0031] In use, the tubing lengths 24, 25 are connected by first making up the connector 16 to one tubing length 24, and then making up the second tubing length 25 to the other end of the connector 16. A number of tubing lengths are connected in this way to form a tubing string, which is run into a wellbore. Once in a desired position, an expansion mandrel is run through the tubing string, and radially extends the connector 16 and the tubing lengths 24, 25. In doing so, the connector slots 18 and tubing slots 12 are expanded to define diamond shaped openings, as are illustrated in Figure 1. As

described above the connector is only subject to substantial deformation at the slot overlaps 34, such that the metal of the slot end portions 20, 21 is subject to minimal deformation. As the deformation of the metal of the connector occurs primarily in the intermediate portion 22, which is of corresponding diameter and thickness to the tubing 24, 25, the expansion properties of the connector 16 are similar to the tubing 24, 25, such that the connector 16 and tubing lengths 24, 25 will expand in corresponding and predictable manner, minimizing the occurrence of irregularities in the internal diameter of the expanded tubing string.

~~[0031]~~[0032] From the above description it will be apparent to those of skill in the art that the assembly 14 provides a convenient means for connecting expandable tubing lengths. It is recognized that, for some applications, users may prefer to include coupling means between the connector end portions and the tubing lengths in addition to the thread connection, and in such cases screws, rivets, pins or the like may be provided to extend between the end portions 20, 21 and the tubing lengths ~~[26, 27]~~24, 25.

~~[0032]~~[0033] Reference is now made to Figures 3 and 4 of the drawings which will illustrate an arrangement 50 for connecting first and second lengths 52, 54 of expandable tubing utilizing an expandable sleeve 56 secured to the ends of the tubing lengths 52, 54 by screws 58. The tubing walls 60, 61 and the sleeve wall 62 define overlapping longitudinal slots 64, 65, 66. Expansion of the tubing lengths 52, 54 and the sleeve 56 is accommodated by deformation of fingers of material 68, 69, 70 where the slots 64, 65, 66 overlap, and following deformation the slots 64, 65, 66 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 72, 73, 74 between the longitudinally spaced slots 64, 65, 66, and the screws 58 pass through bores in the endmost nodes 72, 73, 74 of the tubing lengths 52, 54 and the sleeve 56, at the ends of the tubing lengths 52, 54 and sleeve 56. Thus, the endmost deformable fingers 68, 69 of the tubing lengths ~~[68, 69]~~52, 54 are axially spaced from the endmost fingers 70 of the sleeve ~~[70]~~56.

~~[0033]~~[0034] In use, the tubing lengths 52, 54 and ~~[sleeves]~~sleeve 56 are shipped in disassembled form. The tubing lengths 52, 54 are made up on surface as the tubing is fed into the bore in which the tubing is to be utilized. In particular, the ends of the tubing lengths 52, 54 are located in the respective ends of the sleeve 56. The screws 58 are then located and tightened in the screw bores. A number of tubing lengths are made up to provide the desired length of tubing and the assembled tubing run into the bore. On reaching the desired location downhole, the tubing is anchored in place, and an expansion cone is then pushed or pulled through the tubing. The cone expands the tubing length 52, 54 radially outwards such that, as mentioned above, the slots 64, 65, 66 become diamond-shaped, with the expansion being accommodated by deformation of the fingers 68, 69, 70. The sleeve 56 deforms in a similar manner to the tubing lengths 52, 54. On moving through the arrangement 50, the expansion cone deforms, in turn, the endmost fingers 68 of the first tubing length 52, the fingers 70a at the first end of the sleeve 56, the fingers 70b at the second end of the sleeve 56, and finally the endmost fingers 69 of the second tubing length 54.

~~[0034]~~[0035] In testing it has been found that the forces required to expand the connecting arrangement 50 are the same or only slightly higher than the forces required to expand the tubing lengths 52, 54. Also, the expanded sleeve 56 tends to retain its expanded form, and suffers little or no diametrical shrinkage after the expansion cone has passed through the sleeve 56. Thus, the present invention avoids the difficulties experienced with previously proposed sleeve connectors. Further, the connection arrangement 50 is less expensive to produce than the male\female connectors as described in W096\37687 and W097\21901.

~~[0035]~~[0036] Reference is now made to Figure 5 of the drawings, which illustrates an alternative arrangement 110 for connecting first and second lengths 112, 114 of expandable tubing utilizing an expandable sleeve 116 secured to the ends of the tubing lengths 112, 114 by screws 118. The tubing walls define overlapping longitudinal slots 124, 125. However, unlike the first described embodiment, the sleeve wall is formed of individual longitudinally extending strips 126. Expansion of the tubing lengths 112, 114

and the sleeve 116 is accommodated by deformation of fingers of material 128, 129 where the slots 124, 125 overlap, and circumferential separation of the sleeve strips 126. Following deformation the slots 124, 125 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 132, 133 between the longitudinally spaced slots 124, 125, and the screws 118 pass through bores in the endmost nodes 132, 133 of the tubing lengths 112, 114 and the ends of the sleeve strips 126.

[0036][0037] It will further be apparent for those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the present invention.

ABSTRACT OF THE DISCLOSURE

~~[0037]~~[0038] An expandable tubing assembly comprises a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion. The slots extend over the whole length of the connector, but the only slot overlap occurs in the intermediate portion. The assembly further comprises lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the tubing slots. Tubing threads are formed on the end most tubing nodes. The connector end portions define threads and are coupled with the threads formed on the nodes of the respective end portions of the tubing lengths.

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**EXPANDABLE SLOTTED TUBING STRING
AND METHOD FOR CONNECTING SUCH A TUBING STRING**

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage of International Application No. PCT/GB98/00863, filed on March 20, 1998 and published under PCT Article 21(2) in English, and claims priority of United Kingdom Applications No. 9705928.1 filed on March 21, 1997 and No. 9723338.1 filed on November 4, 1997.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to a connector, and in particular to a connector forming part of an expandable tubing assembly. The invention also relates to a method of connecting lengths of expandable tubing.

Description of the Related Art

[0003] W093\25800 describes expandable tubing defining overlapping longitudinal slots. On expansion of the tubing, by pushing or pulling a mandrel through the tubing, the slots expand to form diamond-shaped apertures. The expansion is accommodated by deformation of the fingers of metal between the slots, this deformation taking place predominantly at the slot ends, and also by circumferential extension of the parts of the tubing wall beyond the slot ends. In expandable tubing developed by the applicants radial expansion is achieved with the parts of the tubing wall between and beyond the slot ends experiencing little if any deformation, these parts being known as the tubing "nodes".

[0004] Arrangements for connecting lengths of slotted tubing are disclosed in W096\37687 and W097\21901, the disclosures of which are incorporated herein by

reference. Both of these documents describe arrangements in which the end of one length of tubing defines a male coupling portion which is received within a female coupling portion on the other length of tubing and attached thereto.

[0005] In another coupling arrangement, the ends of the tubing lengths are received within an external coupling sleeve. However, it has been found that, following expansion, the sleeve contracts radially by a significant extent; this creates a restriction in the bore defined by the tubing.

SUMMARY OF THE INVENTION

[0006] According to the present invention there is provided a method of connecting lengths of expandable tubing defining overlapping longitudinal slots, the method comprising: providing a tubular connector defining overlapping 10 longitudinal slots and comprising end portions; providing lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots and connecting the connector end portions to nodes of respective end portions of the tubing lengths.

[0007] According to another aspect of the present invention there is provided an expandable tubing assembly comprising: a tubular connector defining overlapping longitudinal slots and comprising end portions; lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the slots; and the connector end portions being; coupled to the nodes of the respective end portions of the tubing lengths.

[0008] The formation of the connections between the connector end portions and the nodes of the tubing end portions provides for a relatively secure connection. Preferably, the connector end portions and the nodes of the tubing end portions are threaded, and the absence of significant deformation at the nodes facilitates maintenance of a secure connection on expansion of the tubing lengths and the connector.

[0009] Preferably also, the connector further comprises an intermediate portion selected to be of corresponding configuration to the tubing lengths, such that the expansion characteristics of the connected tubing assembly will be substantially constant over the connection.

[0010] Preferably also, each connector end portion defines a slot to receive a corresponding tongue provided on the respective tubing length end portion.

[0011] According to a further aspect of the present invention there is provided an expandable tubing assembly comprising: a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion; and lengths of expandable tubing defining overlapping longitudinal slots and having end portions coupled to the connector end portions, at least the connector intermediate portion being of corresponding configuration to the tubing lengths, such that the expansion characteristics of the intermediate portion and the tubing lengths correspond.

[0012] This aspect of the invention provides a connector which expands in a compatible manner to the adjacent tubing and thus facilitates reliable expansion of an expandable tubing string.

[0013] According to still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a sleeve defining overlapping longitudinal slots, first and second tubing lengths defining overlapping longitudinal slots, in use the sleeve and tubing lengths being radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths, the deformable fingers of the sleeve being axially spaced from the endmost deformable fingers of the respective tubing lengths.

[0014] In use, on expansion of the tubing lengths and the sleeve, the deformation of the sleeve fingers will take place following the deformation of the endmost fingers of the first tubing length and prior to the deformation of the endmost fingers of the second tubing length. It has been found that, following expansion, there is little or no

diametrical shrinkage of the sleeve, and the force necessary to expand the coupled tubing ends is approximately half that required to expand tubing ends coupled with a sleeve in which there is substantial overlap between the sleeve and the tubing ends.

[0015] The invention also relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of: providing a sleeve defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap; coupling the sleeve to the ends of first and second lengths of expandable tubing such that the fingers of the sleeve are longitudinally spaced from the endmost fingers of the tubing lengths; and forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

[0016] As used herein, the term slots is intended to encompass slots which extend through the walls of the sleeve and tubing, slots which extend only part way through the walls and any other appropriate weakening of the walls such as lines of bores or scallops.

[0017] Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve beyond the respective endmost tubing fingers. The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

[0018] Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

[0019] According to a still further aspect of the present invention there is provided an arrangement for coupling lengths of expandable tubing, the arrangement comprising a longitudinally slotted sleeve and first and second tubing lengths defining overlapping

longitudinal slots. In use, the tubing lengths are radially expandable by deformation of fingers of material where adjacent circumferentially spaced slots overlap, and connecting means for connecting the sleeve to the ends of the tubing lengths.

[0020] The sleeve may be in the form of longitudinally extending strips of metal. Most preferably, the strips are rectilinear. On expansion, the strips of the sleeve move radially outwardly and separate circumferentially. Initially, that is prior to expansion, the strips may be circumferentially connected, by frangible links 119 such as wire, webs of material or one or more welds, to facilitate sleeve handling.

[0021] The invention further relates to a method for coupling the ends of first and second lengths of expandable tubing defining overlapping longitudinal slots and deformable fingers of material where adjacent circumferentially spaced slots overlap, the method comprising the steps of: providing a sleeve comprising longitudinally extending strips of material; coupling the sleeve to the ends of first and second lengths of expandable tubing; and forcing an expansion member through the connected tubing lengths to expand the sleeve and tubing lengths.

[0022] Preferably, the connecting means are provided at circumferentially spaced locations at the end of the tubing lengths beyond the endmost tubing fingers, and at the ends of the sleeve. The connecting means may comprise pins, rivets, screws and the like for location in appropriate aligned bores provided in the sleeve and tubing lengths. Single fasteners may be provided beyond each tubing finger, or multiple fasteners may be provided.

[0023] Preferably also, the unexpanded sleeve is of larger diameter than the tubing lengths. Most preferably, the sleeve and the tubing length are each of substantially constant diameter along their length.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a length of expandable tubing, shown in an expanded configuration;

Figure 2 is a sectional view of an expandable tubing assembly in accordance with a first embodiment of the present invention;

Figure 3 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a second embodiment of the present invention;

Figure 4 is a sectional view of Figure 3; and

Figure 5 is a schematic plan view of an arrangement for coupling lengths of expandable tubing in accordance with a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0025] Reference is first made to Figure 1 of the drawings, which illustrates a length of expandable tubing 10. In its initial configuration, the tubing 10 is simply a length of pipe in which a series of longitudinal slots 12 have been machined. Applying a radially outward force to the tubing wall, by passing a mandrel through the tubing, causes the tubing to expand such that the slots 12 become diamond-shaped openings.

[0026] The tubing 10 is supplied in lengths suitable for transportation and handling and these are joined to one another on surface to create a tubular string. The assembly 14 illustrated in Figure 2 of the drawings allows lengths of expandable tubing 10 to be connected to form a string, as will now be described.

[0027] The assembly 14 comprises a tubular connector 16 defining overlapping longitudinal slots 18, the connector 16 comprising end portions 20, 21 and an intermediate portion 22. The slots 18 extend over the whole length of the connector 16, but the only slot overlap occurs in the intermediate portion 22.

[0028] The connector 16 is utilized to join the ends of two lengths of expandable tubing 24, 25, the ends of which are adapted to engage with the connector end portions 20, 21 as described below.

[0029] The connector intermediate portion 22 is of substantially the same wall thickness as the tubing 24, 25, however the connector end portions 20, 21 are upset, that is they include portions of greater wall thickness than the tubing 24, 25 and are of a greater diameter than the tubing 24, 25. The inner walls of each connector end portion 20, 21 define threads 26, 27 for engaging corresponding threads 28, 29 on the outer surface of the tubing 24, 25. Inwardly of the threads 26, 27 the end portions 20, 21 define grooves 30, 31 to receive corresponding tongues 32, 33 provided on the ends of the tubing lengths 24, 25.

[0030] As noted above, the connector slots 18 only overlap in the intermediate portion 22, such that on expansion of the connector 16 and the tubing lengths 24, 25 the connector 16 is only subject to significant deformation in the intermediate portion 22, at and adjacent the slot overlap 34. The amount of deformation is substantially lower in the rest of the connector 16, particularly in the "nodes" 36 between the ends of the longitudinally aligned slots 18. The tubing lengths 24, 25 feature nodes 38 between and beyond the ends of the tubing slots 12 and the tubing threads 28, 29 are formed on the end most tubing nodes.

[0031] In use, the tubing lengths 24, 25 are connected by first making up the connector 16 to one tubing length 24, and then making up the second tubing length 25 to the other end of the connector 16. A number of tubing lengths are connected in this way to form a tubing string, which is run into a wellbore. Once in a desired position, an expansion mandrel is run through the tubing string, and radially extends the connector 16 and the tubing lengths 24, 25. In doing so, the connector slots 18 and tubing slots 12 are expanded to define diamond shaped openings, as are illustrated in Figure 1. As described above the connector is only subject to substantial deformation at the slot overlaps 34, such that the metal of the slot end portions 20, 21 is subject to minimal deformation. As the deformation of the metal of the connector occurs primarily in the intermediate portion 22, which is of corresponding diameter and thickness to the tubing 24, 25, the expansion properties of the connector 16 are similar to the tubing 24, 25, such that the connector 16 and tubing lengths 24, 25 will expand in corresponding and

predictable manner, minimizing the occurrence of irregularities in the internal diameter of the expanded tubing string.

[0032] From the above description it will be apparent to those of skill in the art that the assembly 14 provides a convenient means for connecting expandable tubing lengths. It is recognized that, for some applications, users may prefer to include coupling means between the connector end portions and the tubing lengths in addition to the thread connection, and in such cases screws, rivets, pins or the like may be provided to extend between the end portions 20, 21 and the tubing lengths 24, 25.

[0033] Reference is now made to Figures 3 and 4 of the drawings which will illustrate an arrangement 50 for connecting first and second lengths 52, 54 of expandable tubing utilizing an expandable sleeve 56 secured to the ends of the tubing lengths 52, 54 by screws 58. The tubing walls 60, 61 and the sleeve wall 62 define overlapping longitudinal slots 64, 65, 66. Expansion of the tubing lengths 52, 54 and the sleeve 56 is accommodated by deformation of fingers of material 68, 69, 70 where the slots 64, 65, 66 overlap, and following deformation the slots 64, 65, 66 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 72, 73, 74 between the longitudinally spaced slots 64, 65, 66, and the screws 58 pass through bores in the endmost nodes 72, 73, 74 of the tubing lengths 52, 54 and the sleeve 56, at the ends of the tubing lengths 52, 54 and sleeve 56. Thus, the endmost deformable fingers 68, 69 of the tubing lengths 52, 54 are axially spaced from the endmost fingers 70 of the sleeve 56.

[0034] In use, the tubing lengths 52, 54 and sleeve 56 are shipped in disassembled form. The tubing lengths 52, 54 are made up on surface as the tubing is fed into the bore in which the tubing is to be utilized. In particular, the ends of the tubing lengths 52, 54 are located in the respective ends of the sleeve 56. The screws 58 are then located and tightened in the screw bores. A number of tubing lengths are made up to provide the desired length of tubing and the assembled tubing run into the bore. On reaching the desired location downhole, the tubing is anchored in place, and an expansion cone is then pushed or pulled through the tubing. The cone expands the tubing length 52, 54

radially outwards such that, as mentioned above, the slots 64, 65, 66 become diamond-shaped, with the expansion being accommodated by deformation of the fingers 68, 69, 70. The sleeve 56 deforms in a similar manner to the tubing lengths 52, 54. On moving through the arrangement 50, the expansion cone deforms, in turn, the endmost fingers 68 of the first tubing length 52, the fingers 70a at the first end of the sleeve 56, the fingers 70b at the second end of the sleeve 56, and finally the endmost fingers 69 of the second tubing length 54.

[0035] In testing it has been found that the forces required to expand the connecting arrangement 50 are the same or only slightly higher than the forces required to expand the tubing lengths 52, 54. Also, the expanded sleeve 56 tends to retain its expanded form, and suffers little or no diametrical shrinkage after the expansion cone has passed through the sleeve 56. Thus, the present invention avoids the difficulties experienced with previously proposed sleeve connectors. Further, the connection arrangement 50 is less expensive to produce than the male/female connectors as described in W096\37687 and W097\21901.

[0036] Reference is now made to Figure 5 of the drawings, which illustrates an alternative arrangement 110 for connecting first and second lengths 112, 114 of expandable tubing utilizing an expandable sleeve 116 secured to the ends of the tubing lengths 112, 114 by screws 118. The tubing walls define overlapping longitudinal slots 124, 125. However, unlike the first described embodiment, the sleeve wall is formed of individual longitudinally extending strips 126. Expansion of the tubing lengths 112, 114 and the sleeve 116 is accommodated by deformation of fingers of material 128, 129 where the slots 124, 125 overlap, and circumferential separation of the sleeve strips 126. Following deformation the slots 124, 125 define diamond-shaped apertures. During expansion there is little or no deformation of the nodes 132, 133 between the longitudinally spaced slots 124, 125, and the screws 118 pass through bores in the endmost nodes 132, 133 of the tubing lengths 112, 114 and the ends of the sleeve strips 126.

[0037] It will further be apparent for those of skill in the art that the above-described embodiment is merely exemplary of the present invention, and that various modifications and improvements may be made thereto, without departing from the scope of the present invention.

ABSTRACT OF THE DISCLOSURE

[0038] An expandable tubing assembly comprises a tubular connector defining overlapping longitudinal slots, the connector comprising end portions and an intermediate portion. The slots extend over the whole length of the connector, but the only slot overlap occurs in the intermediate portion. The assembly further comprises lengths of expandable tubing defining overlapping longitudinal slots and having end portions defining nodes between and beyond the ends of the tubing slots. Tubing threads are formed on the end most tubing nodes. The connector end portions define threads and are coupled with the threads formed on the nodes of the respective end portions of the tubing lengths.